

China's Upgrading Trajectory in the Global Electronics Industry

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Abstract

In this paper, we make use of a unique world electronics production data set to assess China's upgrading trajectory in the global electronics industry. Contrary to existing studies, we find no evidence that China's electronics production activities are more sophisticated than one would expect from its level of development. We also find little evidence that China is rapidly upgrading into more sophisticated production activities.

JEL classification: O10, O14, L63.

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1 Introduction

China's economy seems to be upgrading rapidly. While fifteen years ago China was primarily an exporter of low-tech products such as apparel, toys and footwear, today it has become the world's largest exporter of electronics products (OECD, 2005). This has instilled in the Western world a growing fear that China is rapidly moving up the technology ladder, thus becoming increasingly competitive in the West's comparative advantage sectors.

A number of recent studies have used trade data to provide empirical evidence that China indeed has become more sophisticated than one would expect from its level of development. Rodrik (2006) and Hausmann *et al.* (2007) have created a methodology to assess a country's position on the technology ladder by analyzing the composition of its export bundle.¹ As a starting point, they use the rationale that an export good is more sophisticated the higher the weighted average income of its exporting countries. They then use the country's export composition to estimate the degree of sophistication of its export bundle vis-à-vis that of the rest of the world. Rodrik (2006) and Hausmann *et al.* (2007) find that the bundle of goods that China exports is similar in sophistication to those of countries with income levels three times higher than that of China, thus leading Rodrik (2006) to conclude that "China has somehow managed to latch on to advanced, high productivity products that one would not normally expect a poor, labor abundant country like China to produce, let alone export."

Using a similar logic, Schott (2006) has recently used Finger and Kreinin's (1979) export similarity index to demonstrate that China's exports are surprisingly similar to OECD's export structure. This has led Schott (2006) to conclude that "China's export bundle increasingly overlaps with that of more developed countries, rendering it more sophisticated than countries with similar endowments."

The main shortcoming of the above-mentioned studies is that trade patterns are a poor indicator of a country's set of comparative advantage goods (Baldone *et al.*, 2006; Van Assche, 2006). International trade data are generally collected and reported as gross flows rather than as foreign value added, thus making it difficult to attribute the type of production activities that have taken place in an exporting country (Grossman and Rossi-Hansberg, 2006). Indeed, in a world with international production fragmentation and intermediate good trade, a country's exports does not necessarily reflect the embodied technology and relative endowments that have gone into the coun-

¹Lall *et al.* (2006) have developed a similar approach, but did not focus on China.

try’s domestic production activities, but may simply reflect the technology and factors of the countries from which it imports intermediate goods. To illustrate this, consider an export good z that is produced through the assembly of inputs x and y . In Figure 1, we depict two scenarios. In Scenario 1, the production of the inputs x and y and the assembly of product z all occur at home. In Scenario 2, the inputs x and y are imported from abroad, while only the assembly occurs at home. Although the amount and type of production activities differ in both scenarios, the export pattern is identical. This implies that export data will overestimate a country’s production activities in industries with a large share of processing trade.²

Two features of China’s export system suggest that its estimated sophistication level is likely to be biased upward more than other countries. First, China’s foreign trade expansion in the last few decades is mainly due to a rise in processing exports. In 1986, processing exports accounted for only 18 percent of China’s total exports, while in 2005 it has risen to more than 55 percent (Naughton, 2007). Second, the share of processing exports in total exports has consistently been higher in high-tech industries such as electronics than more traditional industries such as textiles, leather and shoes (Gaulier *et al.*, 2005). These two characteristics suggest that the existing literature’s result that China’s export bundle is relatively more sophisticated than one would expect from its level of economic development might be a statistical mirage.

In this paper, we provide an alternative estimate of China’s position on the global technology ladder by making use of a unique data set of world electronics production compiled by Reed Electronics Research. Contrary to existing studies, we find no evidence that China’s electronics production activities are more sophisticated than one would expect from its level of development. We also find little evidence that China is rapidly upgrading into more sophisticated production activities.

2 Data and Methods

The Reed Electronics Production Data Set (REP) measures a country’s domestic production by electronics subcategories for 51 countries. The coverage and degree of disaggregation in the REP varies between countries, but we have been able to extract a consistent panel for 13 electronics subcate-

²Processing trade encompasses imports of goods to be assembled or transformed in China and re-exported, within international assembly and subcontracting operations. These imported inputs are exempted from tariffs.

gories from 1992 to 2005 (See Table 1 for the list of product subcategories).

[Table 1 about here]

In Table 2, we present summary statistics from the REP data set. The table clearly identifies the emergence of China (and the rest of developing East Asia) as a dominant player in the global electronics industry. China's electronics production has grown at a remarkable rate of 24.8 percent between 1992 and 2005. As a result, China's share of world electronics production has risen from 1.9 percent in 1992 to 18.4 percent in 2005. With a value of production of 260.1 billion U.S. dollars, it has surpassed that of the European Union and Japan, just lagging behind the U.S. electronics production value.

[Table 2 about here]

The rapid rise in China's share of global electronics production, however, does not necessarily mean that China is technologically upgrading. The electronics sector is a highly heterogeneous industry that consists of production activities that vary greatly in their sophistication levels. If China is primarily specialized in production activities with low sophistication levels, then China's rise in the global electronics industry does not necessarily go hand-in-hand with technological upgrading. To analyze China's position on the global technological ladder, it is therefore necessary to take into account the composition of production activities that take place within its electronics industry. In Table 3, we present the average RCA indices for the various subcategories of China, the ASEAN-4 (Indonesia, Malaysia, the Philippines and Thailand), the NIEs (Hong Kong, Singapore, South Korea and Taiwan), Japan, the United States and the EU-15 in 1992-1994 and 2003-2005.³ The production specialization patterns vary greatly across countries. In 2003-2005, for example, China was particularly specialized in the electronics sub-categories *audio equipment*, *electronic data processing (EDP)*, *other components* and *video equipment*. The United States, on the other hand,

³The revealed comparative advantage (RCA) index is generally calculated as a country c 's share of world exports of a good i divided by its share of total world exports: $RCA = (\frac{x_{i,c}}{X_c}) / (\frac{\sum_c x_{i,c}}{\sum_c X_c})$. In this paper, we use the same methodology, but use production data instead of export data.

was specialized in the production of very different sub-categories including *x-ray & medical equipment, control and instrumentation, office equipment* and *radio communications & radar*.

Even if China is at a lower echelon of the global technological ladder, it can upgrade by gradually specializing in more sophisticated production activities. By comparing China's RCA indices in 1992-1994 and 2003-2005, it is apparent that China indeed has been changing its specialization patterns over the last few decades. Specifically, its electronics industry has become more specialized in sub-categories *EDP* and *radio communications & radar*, while becoming less specialized in *personal consumer electronics* and *audio equipment* among others (see Table 3).

To estimate China's position on the technology ladder as well as its upgrading trajectory in the electronics industry, we use a methodology similar to Rodrik (2006) and Hausmann *et al.* (2006). In a first step, we estimate the level of sophistication of a product as the average income of its producers. The rationale behind this is that, in the absence of trade interventions, richer countries generally will have characteristics that allow them to have a comparative advantage in high wage industries. These characteristics may include high capital abundance, the embodiment of higher-level technology and better institutions. Let $x_{i,c}$ denote the production value of electronics subcategory i in country c , $X_c = \sum_i x_{i,c}$ equal country c 's total electronics production value and Y_c country c 's per-capita GDP in current prices. Then the level of production sophistication S for good i equals

$$S_i = \sum_c \frac{x_{i,c}/X_c}{\sum_c (x_{i,c}/X_c)} Y_c. \quad (1)$$

It is straightforward to rearrange equation (1) so that a country's weight is a function of all countries' revealed comparative advantage index (RCA):

$$S_i = \sum_c \omega_{i,c} Y_c \quad (2)$$

where

$$\omega_{i,c} = \frac{\text{RCA}_{i,c}}{\sum_c \text{RCA}_{i,c}}.$$

Equation (2) suggests that there are two reasons why a good's sophistication index may increase. First, it may increase because rich countries increase their specialization in the production of good i . Second, it may increase because the countries that are specialized in good i get relatively richer than the rest of the world.

Once the sophistication index has been estimated for all goods i , one can calculate a country’s technology index CTI as the weighted average of the sophistication levels of the products that it produces:

$$CTI_c = \sum_i \theta_{i,c} S_i. \quad (3)$$

where a product’s weight $\theta_{i,c}$ equals the share of good i in country c ’s total electronics output:

$$\theta_{i,c} = \frac{x_{i,c}}{X_c}.$$

3 Results

In this Section, we present the results in three parts. In subsection 3.1, we discuss how electronics subcategories are ranked in terms of their degree of sophistication and how this has changed over time. In subsection 3.2, we then analyze how China’s estimated technology index compares to other countries. Finally, in subsection 3.3, we compare China’s technology index to its level of development.

3.1 Product Sophistication Index

In Table 3, we have presented the average sophistication index for the various electronics subcategories in 1992-1994 and 2003-2005 respectively. We can make a couple of observations concerning the sophistication rankings. First, it might seem surprising that *personal consumer electronics* is ranked as the most sophisticated electronics subcategory, since it primarily accounts for items such as electronics clocks and watches. This can be explained by the fact that the world’s richest country —Switzerland — produces almost a third of the total value of *personal consumer electronics*.

Second, the ranking of electronics subcategories has remained fairly stable across time. The three most sophisticated subcategories are consistently *personal consumer electronics*, *x-ray & medical equipment* and *control & instrumentation*, while the four least sophisticated products are *video equipment*, *audio equipment*, *office equipment* and *industrial equipment*.

Third, there is one electronics subcategory that has seen a dramatic change in ranking: *EDP*. In 1992-1994 it was ranked as the 4th most sophisticated product, while in 2003-2005 it had dropped to 9th place. This drop in ranking is because developed countries in the last two decades have significantly reduced their specialization in *EDP*, while developing countries

have increased their specialization. Indeed, the RCA index for *EDP* of developing countries including China, the ASEAN-4 countries, Mexico and a number of Eastern European countries all have increased significantly between 1992 and 2005. At the same time, many EU-15 countries, Japan, the United States and Canada have reduced their specialization in *EDP*. This trend can be attributed to the large-scale offshoring of *EDP* assembly plants by multinational firms to developing countries primarily in East Asia (Derdrick and Kraemer, 1998; Bonham *et al.*, 2006).

[Tables 3 about here]

3.2 Country Technology Index

In Table 4, we present the Country Technology Index (CTI) in the global electronics industry. A number of observations stand out. First, Switzerland and the Scandinavian countries Denmark, Norway, Finland and Sweden have the highest technology index in 2003-2005 due to their high specialization in the most sophisticated subcategories *personal consumer electronics*, *x-ray & medical equipment control & instrumentation* and *radio & radar communications*. In Switzerland, for example, almost a third of its electronics production in 2005 was *personal consumer electronics* and a quarter of its electronics production was *control & instrumentation*. Two thirds of Finland's electronics production in 2005 was *radio & radar communications*.

[Table 4 about here]

Second, the very high ranking of Saudi Arabia and Puerto Rico may be surprising. For Saudi Arabia, this is due to their high specialization in *radio & radar communications* and *x-ray & medical equipment*. For Puerto Rico, this is due to the fact that 44.1 percent of its electronics production value in 2005 was *x-ray & medical equipment*.

Third, our analysis provides little evidence that China has rapidly moved up the global technological ladder since 1992. While China was ranked 42nd in 1992-1994, it has only moved up to the 39th position in 2003-2005.

3.3 CTI vs. Level of Development

A final question that our paper addresses is how China's technology level compares to its level of economic development. In Figure 2, we show the scatter plot of TCI against per-capita GDP in 2003-2005. The correlation coefficient is 0.64. Contrary to Rodrik (2006) and Hausmann *et al.* (2007), we do not find that China lies significantly above the regression line. Rather, we find that China lies dead on the regression line, implying that we find no empirical evidence that China's technology level is higher than one would expect from its level of development.

[Figure 2 about here]

4 Conclusion

In this paper, we have made use of a unique world electronics production data set to assess whether China's electronics industry is more sophisticated than one would expect from its level of development. Contrary to existing studies, we find no evidence of this, nor do we find evidence that China is rapidly upgrading into more sophisticated production activities.

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Table 1: Product categories

Mnemonic	Category	Type of Products
EDP	Electronic data processing	<i>Computers, peripherals</i>
OFF	Office equipment	<i>Photocopiers, electronic calculators</i>
CON	Control and instrumentation	<i>Measuring instruments, control systems</i>
XME	X-ray and medical equipment	<i>X-ray equipment, electromedical equipment</i>
IND	Industrial equipment	<i>Traffic signaling, security and fire alarms</i>
COM	Radio communications and radar	<i>Mobile radio telephones, pagers</i>
TEL	Telecommunications	<i>Telephones, fax, answering machines</i>
VID	Video equipment	<i>Television, video camera, DVD player</i>
AUD	Audio equipment	<i>Portable audio, car audio, CD player</i>
PCE	Personal consumer equipment	<i>Electronic clocks, electronic watches</i>
ACT	Active components	<i>Integrated circuits, diodes, transistors</i>
PAS	Passive components	<i>printed circuit boards, relays, switches</i>
OTH	Other components	<i>Microphones, loudspeakers, amplifiers</i>

Source: Reed Yearbook of World Electronics Data

Table 2: Developments in Electronics Production

Country	Electronics Production (\$ Mill)			CAGR (%) 1992–2005	Share of world electronics production (%)		Electronics production /GDP (%) 2005
	1992	2005	2005		1992	2005	
China	14,626	260,161		24.8	1.9	18.4	11.7
United States	212,757	282,697		2.2	28.3	20.0	2.3
EU 15	173,679	225,689		2.0	23.1	15.9	1.8
Japan	193,417	192,878		-0.0	25.7	13.6	4.2
NIEs	73,684	200,139		8.0	9.8	14.1	14.0
<i>Hong Kong</i>	<i>8,499</i>	<i>3,874</i>		<i>-5.9</i>	<i>1.1</i>	<i>0.3</i>	<i>2.2</i>
<i>South Korea</i>	<i>25,970</i>	<i>106,561</i>		<i>11.5</i>	<i>3.5</i>	<i>7.5</i>	<i>13.5</i>
<i>Singapore</i>	<i>20,244</i>	<i>48,373</i>		<i>6.9</i>	<i>2.7</i>	<i>3.4</i>	<i>41.4</i>
<i>Taiwan</i>	<i>18,980</i>	<i>41,331</i>		<i>6.2</i>	<i>2.5</i>	<i>2.9</i>	<i>12.0</i>
ASEAN-4	22,591	97,584		11.9	3.0	6.9	14.2
<i>Indonesia</i>	<i>2,169</i>	<i>11,352</i>		<i>13.6</i>	<i>0.3</i>	<i>0.8</i>	<i>4.0</i>
<i>Malaysia</i>	<i>12,361</i>	<i>48,968</i>		<i>11.2</i>	<i>1.6</i>	<i>3.5</i>	<i>37.4</i>
<i>Philippines</i>	<i>1,949</i>	<i>13,915</i>		<i>16.3</i>	<i>0.3</i>	<i>1.0</i>	<i>14.1</i>
<i>Thailand</i>	<i>6,112</i>	<i>23,349</i>		<i>10.9</i>	<i>0.8</i>	<i>1.6</i>	<i>13.5</i>
Total Market	752,961	1,415,222		5.0	100	100	3.2

Source: Year-book of World Electronics Data. GDP from IMF

Table 3: Product sophistication index

	RCA															Soph. index																			
	China					ASEAN-4					NIEs					Japan					United States					EU-15					ROW				
	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005	1992-1994	2003-2005							
PCE	4.39	1.52	0.74	0.80	1.99	0.63	0.93	0.85	0.70	0.58	0.33	0.42	0.30	0.32	1.13	1.60	1																		
XME	0.25	0.13	0.14	0.10	0.11	0.13	0.85	0.70	0.57	0.70	1.53	2.07	1.15	1.54	1.12	1.52	2																		
CON	0.26	0.18	0.14	0.21	0.11	0.10	0.44	0.57	0.91	0.57	1.48	1.80	1.70	2.16	1.53	1.76	3																		
COM	0.51	0.71	0.42	0.29	0.32	1.09	0.50	0.91	0.91	0.91	1.84	1.40	1.09	1.18	1.01	1.05	4																		
PAS	1.38	0.82	0.73	1.05	1.02	0.90	1.21	1.63	0.81	1.63	0.81	0.69	1.05	1.15	0.99	1.05	5																		
TEL	0.80	0.88	0.62	0.49	0.50	0.33	0.82	0.58	0.88	0.58	0.88	1.29	1.59	1.46	1.53	1.53	6																		
OTH	1.77	1.66	0.95	1.45	1.58	0.93	1.14	0.88	0.76	0.88	0.76	0.55	0.84	1.00	0.84	0.93	7																		
ACT	0.55	0.25	1.83	1.84	1.56	1.94	1.42	1.73	1.04	1.73	0.90	0.87	0.45	0.61	0.44	0.47	8																		
EDP	0.59	1.75	0.81	1.15	1.33	0.99	1.04	0.67	0.94	0.67	0.94	0.80	0.95	0.78	0.95	0.85	9																		
IND	1.15	0.61	0.39	0.24	0.44	1.11	0.61	0.63	0.91	0.63	0.91	1.22	1.62	1.47	1.71	1.40	10																		
OFF	1.53	1.14	0.70	0.46	0.59	0.48	1.24	1.02	1.02	1.02	1.02	1.44	1.00	1.03	0.91	0.97	11																		
AUD	4.99	2.12	3.41	2.10	1.68	0.72	1.39	0.73	0.73	0.73	0.02	0.13	0.45	0.70	0.73	1.00	12																		
VID	2.18	1.58	2.42	1.35	1.11	0.57	1.30	1.35	1.35	1.35	0.33	0.22	0.81	0.43	1.06	1.19	13																		

Source: Authors' calculations using Reed Yearbook of World Electronics Data

Table 4: Country technology index

Rank in 2003-2005	1992-1994	1998-2000	2003-2005
Switzerland	1	1	1
Denmark	5	6	2
Norway	4	4	3
Finland	15	3	4
Sweden	7	2	8
Saudi Arabia	3	17	6
Puerto Rico	8	25	7
Netherlands	6	15	8
Germany	17	7	9
Croatia	12	11	10
Canada	11	14	11
New Zealand	2	5	12
United States	13	8	13
Ukraine	47	13	14
Australia	16	9	15
Italy	14	18	16
France	20	12	17
Israel	18	10	18
Bulgaria	28	32	19
Austria	44	36	20
United Kingdom	19	20	21
Greece	36	29	22
Slovenia	21	24	23
Venezuela	22	21	24
Romania	34	19	25
Hong Kong	9	16	26
Ireland	10	22	27
Belgium	26	37	28
South Korea	43	23	29
South Africa	33	34	30
Japan	29	28	31
Philippines	38	26	32
Taiwan	24	30	33
Singapore	27	31	34
Czech Rep.	25	33	35
Russia	41	35	36
Brazil	32	38	37
Hungary	23	46	38
China	42	40	39
Malaysia	49	41	40
Thailand	37	39	41
Slovakia	40	27	42
Spain	31	43	43
India	35	45	44
Portugal	39	49	45
Vietnam	51	48	46
Indonesia	48	44	47
Poland	30	42	48
Egypt	45	50	49
Mexico	46	47	50
Turkey	50	51	51

Source: Authors' calculations using Reed Yearbook of World Electronics Data

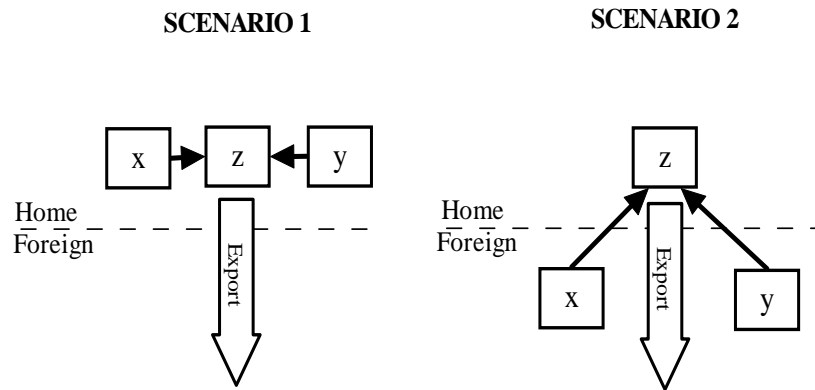


Figure 1: Ordinary versus processing trade.

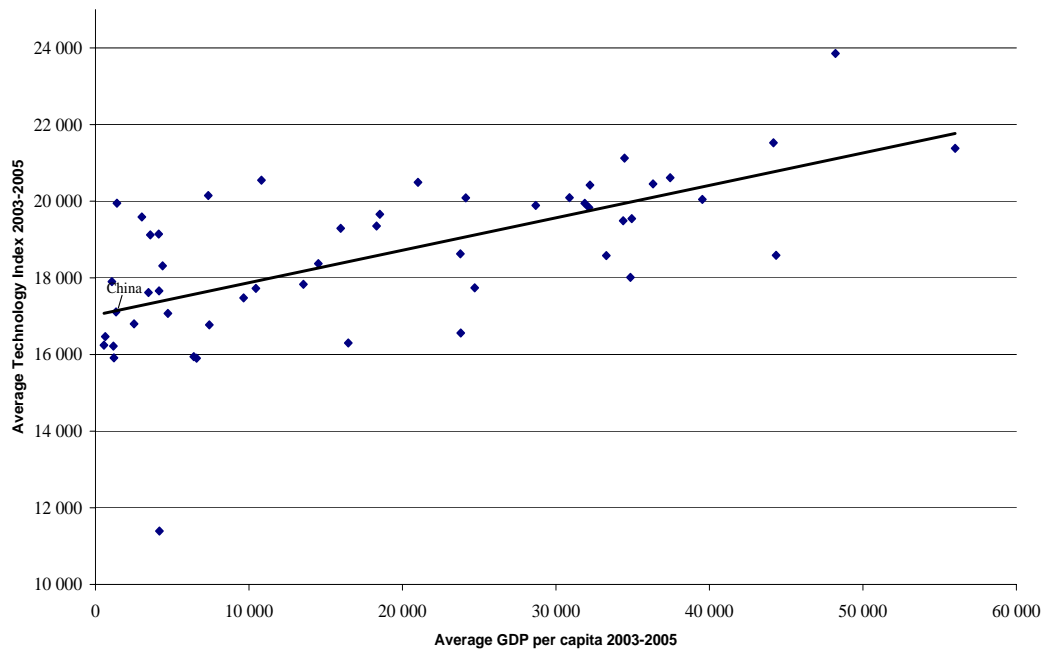


Figure 2: CTI versus GDP per capita.